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Technical Memorandum

Prepared for: City of Durham Stormwater Services

Project Title: Proposed Stormwater Control Measure Retrofit at Former Duke Diet and Fitness Center Site

Project No: 140368

Technical Memorandum No. 1

Subject: Conceptual Stormwater Control Measure Water Quality Analysis

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1. Introduction

The purpose of this Technical Memorandum is to provide a preliminary engineering evaluation of a regional stormwater control measure (SCM) focused on water quality at the location of the former Duke Diet and Fitness Center facility (DDFC), which was located on a 9-acre parcel at the corner of West Trinity and North Duke Streets near downtown Durham (see Figure 1).

Included in this memorandum is:

- A brief summary of the existing site conditions, jurisdictional natural resources, and potential environmental issues at the site
- A discussion of each of the three proposed Concept Design Alternatives
- Procedures and results for the Hydrologic and Hydraulic modeling of the Alternatives
- A discussion of the estimated water quality benefits for each Concept Design Alternative based on the Jordan/Falls Lake Stormwater Nutrient Load Accounting Tools
- A discussion of Analysis Results

1.1 Current Site Conditions

The DDFC site contains a building, parking area, and recreational fields (see Figure 2), which are not currently used by Duke University. The site is located at the headwaters of South Ellerbe Creek at the confluence point of the Trinity and Downtown Basins, two heavily developed urban basins near downtown Durham (see Figure 1).

The Trinity Basin, which consists of 230 acres of heavily urbanized residential and commercial land near downtown Durham, discharges into the headwaters of South Ellerbe Creek in the southwest corner of the site through an existing 7'H X 8'W box culvert. The Downtown Basin, which consists of 255 acres of heavily urbanized residential, commercial, and industrial land in the downtown business district, discharges into South Ellerbe Creek near the northern property line through a buried 8'H X 10'W arch culvert. This arch culvert is in poor condition and is failing. An active 18" PVC sanitary sewer line and an abandoned 18" VCP line run parallel to the arch culvert across the entire site. A greenway path runs along the eastern and northern property boundaries and crosses the tributary to Ellerbe on the northwest property corner. A railroad embankment runs along the eastern property line, and a Duke Power facility is located just north of the property.

Four other potential site constraints may affect the design and performance of the proposed SCM at the DDFC site: (1) the extent of the FEMA-regulated floodplain, (2) the presence of jurisdictional natural resources such as streams and wetlands, (3) environmental clean-up issues due to previous land use activities on the site or adjacent properties, and (4) subsurface physical conditions (i.e., depth to bedrock) which may limit water quality or flood storage volumes, or increase construction costs.

1.1.1 FEMA-Regulated Floodplain

Flood Insurance Rate Maps for Durham indicate that almost the entire DDFC site is located within the 100-year floodplain, which varies in elevation from 324.8 ft MSL at the northern property line to 326 ft MSL at Trinity Ave. Part of the existing building is located within the regulated floodway. Any grading activities on the site to create the SCM would have to balance the needs for flood storage so that a "no-rise certification" can be achieved, which indicates that the SCM will not increase the risk of flooding to surrounding properties.

1.1.2 Jurisdictional Waters of the U.S.

In July 2011, an assessment was completed of the presence of jurisdictional waters of the United States, including streams and wetlands, on the DDFC site that would fall under the jurisdiction of the U.S. Army Corps of Engineers and the North Carolina Division of Water Quality (EcoEngineering, July 2011). The preliminary assessment identified one perennial stream, known as South Ellerbe Creek, as the only jurisdictional resource on the site. Any temporary or permanent impacts to South Ellerbe Creek as a result of this project would have to be permitted through these two regulatory agencies.

1.1.3 Phase I and II Environmental Site Assessments

A Phase I Environmental Site Assessment (ESA) of the DDFC site was completed by EcoEngineering in August, 2011. The significant findings of the ESA included the following:

- The existing building may contain asbestos-containing material (ACM) and lead-based paint (LBP)
- Solid waste debris piles were observed on-site. One pile, located near South Ellerbe Creek, contains large pieces of asphalt
- Three PVC pipes were observed protruding from the ground. These pipes appear to be associated with the on-site pool and drainage culvert, but this could not be verified due to access limitations
- One aboveground storage tank (AST) that previously stored propane was observed on-site
- Several off-site properties were identified as a recognized environmental condition (REC) for the site

The recommendations of the Phase I ESA included the following:

1. If the on-site building is going to be demolished, a survey for ACM and LBP should be conducted and any identified ACM and LBP should be mitigated in accordance with applicable regulations prior to initiating building demolition activities
2. The source and use of the PVC piping should be determined
3. The AST should be removed in accordance with applicable regulations
4. A limited Phase II ESA should be performed to determine if contaminants are present in the soil and groundwater beneath the site. The potential sources of the contaminants include the on-site debris piles and the identified off-site RECs.

Recommendations 2 and 3 can be resolved as part of building demolition activities. Recommendations 1 and 4 were completed as part of a limited Phase II ESA performed by Brown and Caldwell on December 19, 2011 (Brown and Caldwell, *Results of Limited Phase II Investigation*, March 16, 2012). The limited Phase II ESA focused on whether contaminants originating from the potential sources are present in soil and groundwater beneath the site. Limited ACM, LBP, soil, and groundwater sampling was performed as part of the Phase II ESA.

The field work completed as part of the limited Phase II ESA included:

1. An asbestos and LBP survey for the on-site building
2. Conducting soil sampling in the vicinity of the asphalt debris pile (see Figure 3) to determine if the debris pile had impacted the subsurface. Soil samples were collected at 1 and 5 feet below ground surface (bgs).
3. Installing four temporary wells, TW-1 through TW-4 (Figure 3), and collecting groundwater samples from these temporary wells to determine whether nearby off-site properties and/or the on-site debris piles have impacted the groundwater beneath the DDFC site

4. Surveying and subsequently destroying the temporary wells by removing the well casing and backfilling the borehole with a cement/bentonite grout mixture

Based on the results of the limited Phase II ESA, the following conclusions were provided:

- Semi-volatile Organic Compounds (SVOCs) were detected in the 1-foot below ground surface (bgs) soil sample collected at TW-2 (Figure 3) at concentrations above the State of North Carolina Department of Environmental and Natural Resources (NCDENR) Preliminary Soil Remediation Goals (PSRGs) and United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) for residential and groundwater protection. The likely source of the SVOCs detected in TW-2 is the asphaltic material within the large debris pile located north of the existing building (Figure 3). Runoff from the debris pile may contain SVOCs which may be impacting the surrounding area and possibly South Ellerbe Creek.
- The lateral extent of the soil impacts identified in TW-2 has not been delineated
- The vertical extent of the soil impacts identified in TW-2 is between 2 and 5 feet bgs
- Groundwater flow on December 19, 2011 was in an easterly direction away from South Ellerbe Creek
- Contaminants were not detected in groundwater
- ACM and LBP are present in the building

The following is a summary of recommendations based on the results of the limited Phase II ESA:

- Submit a Notice of Discharge to NCDENR, as soon as possible. Any detectable amount of a contaminant is considered a release by NC statute and must be reported, generally within 24 hours of discovery.
- Define the lateral extent of SVOCs detected in TW-2 and collect additional soil samples adjacent to the other sides of the debris pile. The investigation should follow NCDENR guidelines for assessment and cleanup.
- If the debris pile is removed, it should be disposed at a facility permitted to accept the material. Confirmation soil samples should be collected below the debris pile to ensure that all contaminants are removed from underneath the debris pile. The remedial action should follow NCDENR guidelines.
- If there are no plans to immediately remove the soil stockpile, it should be covered with impermeable material (such as visquene) as an interim measure to stop the 'release'. The impermeable cover should be maintained so that precipitation can no longer run-off the pile or migrate through the stockpile to the underlying soil.
- Demolition and/or renovation work in which ACM and LBP is disturbed must be performed in compliance with EPA, OSHA and the State of North Carolina regulations. ACM will require abatement by a North Carolina licensed asbestos abatement contractor prior to demolition/renovation activities. ACM waste should be taken to an approved landfill. Work must be performed in accordance with NESHAP asbestos regulations, 40 CFR 61, Subpart M, and OSHA regulations 29 CFR 1910 and 1926.

1.1.4 Subsurface Physical Conditions

The depth to bedrock investigation at the DDFC site was performed on March 15, 2012. The field work consisted of the following activities:

- Marking the proposed boring locations for clearance by the public underground locating service (North Carolina 811)

- Drilling 40 soil borings at the DDFC site (Figure 4) using direct-push drilling methodology. Bedrock was assumed present at depths where 'refusal' of the push-rods occurred. Depth to groundwater could not be measured due to borehole collapse when the push-rods were removed. Drilling was conducted by Geologic Exploration.
- Backfilling each borehole to the surface with bentonite pellets
- Surveying each borehole location to mean sea level datum. Surveying was completed by CH Engineering, a North Carolina licensed surveyor.

Bedrock was encountered between 3 and 18 feet bgs across the DDFC site (Figure 4). Silty clay was generally present throughout the Site and graded into sandier material with depth until bedrock was encountered. Bedrock highs were observed in the northern and eastern portions of the site with bedrock lows (possible former stream channel) generally present in the center portion of the site.

Based on the results of the Phase II ESA, groundwater was encountered between 5 and 7 feet bgs. During the Phase II ESA, groundwater was not observed in the eastern portion of the site near temporary well TMW-1 (Figure 4) which indicates that the groundwater may be perched on the bedrock and may be localized around South Ellerbe Creek.

2. Concept Designs

Three conceptual design alternatives were developed to provide water quality treatment for the Trinity and Downtown basins at the DDFC site. The concept design alternatives assumed the following site modifications:

- Removal of the building, parking areas, and all other existing site improvements
- Removal of the failing 8'H X 10'W arch culvert that drains the Downtown Basin and installation of a new outfall at Trinity Avenue
- Removal of the abandoned 18" VCP sewer line, and relocation of the active 18-inch PVC sanitary sewer pipe that runs parallel to the 8'H X 10'W arch culvert
- Relocation of the existing greenway trail onto the northern berm created for the proposed SCM

Two of the alternatives (Options 1A and 1B) include conversion of the site to an off-line wet pond with adequate storage above the permanent pool elevation to detain, store, and treat the water quality volume. Option 1A is designed to treat only stormwater flows from the Downtown Basin, while Option 1B provides a design that will treat both the Trinity and Downtown Basins. In both alternatives, the wet pond would occupy the upland area to the east of South Ellerbe Creek without any direct impacts to the creek.

The third alternative (Option 2) includes conversion of the site to an on-line constructed wetland to provide water quality treatment for the Trinity and Downtown Basins. This alternative would involve integration of South Ellerbe Creek into the wetland design, which may be considered a jurisdictional impact. However, the design would include enhancements to South Ellerbe Creek and daylighting of the buried arch culvert into a natural stream, which may serve to offset any impacts to South Ellerbe Creek.

The conceptual design alternatives presented in this memo do not address any recreational amenities or community enhancements to the project. They are to be addressed during the preliminary/final design phase if the project moves forward and a preferred concept is selected for further design. To evaluate the water quality benefits of each conceptual design, all three alternatives are based on the following design criteria specified in the City's 2011 Reference Guide for Development:

- Treat the City's water quality design storm which equals 1 inch of rainfall across the contributing drainage basin; rainfall amounts for other design storms are:

- 1-year, 24-hour rainfall amount: 3.0-inches
- 2-year, 24-hour rainfall amount: 3.5-inches
- 10-year, 24-hour rainfall amount: 5.1-inches
- 25-year, 24-hour rainfall amount: 6.0-inches
- 100-year, 24-hour rainfall amount: 7.4-inches

- Minimum 10-foot wide access path along the top of the berm, which will allow relocation of the existing greenway trail to the top of the berm
- Embankment shall meet the requirements for a Class A dam
- Principal spillway is activated during the 25-year design storm
- Adequate freeboard is provided for the 100-year design storm
- A 10-foot wide aquatic bench is provided at the permanent pool elevation for wet ponds
- Sediment forebays should equal at least 20% of the permanent pool volume
- Drawdown times for the water quality design storm should be 2-5 days

2.1 Wet Pond Alternatives – Options 1A and 1B

2.1.1 Option 1A – Pond Alternative to Treat Downtown Basin

The conceptual design for Option 1A (see Figure 5) includes conversion of the eastern portion of the site to an off-line wet pond that provides stormwater treatment for only the Trinity Basin. In addition to the site modification listed above, construction of this wet pond will involve excavating the floodplain to an approximate elevation of 310 ft MSL (8-12 feet of soil removal) to form the base of the pond and creation of a perimeter berm to form the pond (shown at elevation 324 ft MSL).

This design will provide a permanent pool depth of six feet and up to three feet of live storage. The wet pond outlet structure would be located along the northern portion of the embankment to discharge directly into South Ellerbe Creek. The existing greenway could be located along the top of the berm to maintain the recreational use of the trail and provide the City with maintenance access. Based on the proposed dam height (Class A dam), the outlet structure will likely need to pass the 100-year event without overtopping the berm, depending on the final grading plan and dam height.

The conceptual design for the wet pond includes a forebay with a separation embankment that is submerged 6-inches below the permanent pool elevation. This forebay will serve to provide removal of coarse sediments and to dissipate the velocity of high flows from the outfall.

2.1.2 Option 1B – Pond Alternative to Treat Trinity and Downtown Basins

The general grading and permanent pool configuration of Option 1B (see Figure 6) is similar to the conceptual design provided for Option 1A with one modification: installation of a diversion structure at the existing outfall point for the Trinity Basin. All stormwater flows from the Downtown Basin would still enter the wet pond, and a portion of the flows from the Trinity Basin would enter the wet pond through the diversion structure, which would function as follows:

- Year-round base flows from the Trinity Basin would be discharged directly into South Ellerbe Creek and bypass the off-line wet pond
- Increased flows in the Trinity Basin due to rainfall, up to the peak flow generated by the City's water quality design storm, would be directed into the off-line wet pond for treatment

- Flows generated by rainfall in the Trinity Basin above the peak flow generated by the City's water quality design storm (e.g., 1-year through 100-year design storms) would be directed into South Ellerbe Creek, bypassing the off-line wet pond. This would help protect the wet pond from high flows generated by extreme storm events in both basins.

All other site modifications listed under Option 1A would be necessary for Option 1B. Since only moderate flows will be directed into the wet pond from the Downtown Basin, the diversion pipe may discharge directly into the wet pond, or it can be extended to discharge into the sediment forebay. This design will provide a permanent pool depth of six feet and up to three feet of live storage. Modeling results (see Section 3). Based on the proposed dam height (Class A dam), the outlet structure will likely need to pass the 100-year event without overtopping the berm, depending on the final grading plan and dam height.

2.2 Constructed Wetland Alternative – Option 2

Option 2 (see Figure 7) consists of conversion of the entire DDFC site into an on-line constructed wetland that will be designed to treat the stormwater discharges from both basins. In addition to the site modification listed above, this proposed constructed wetland will involve the following site modifications:

- Excavation of the site to an approximate elevation of 315 to 316 ft MSL (6-9 feet of soil removal) to form the wetland terrace (low marsh and high marsh) at the base of the wetland
- Excavation of several deep pools approximately two feet below the wetland terrace elevation
- Creation of separate meandering streams from the two outfalls that pass through the deep pools and connect at the outlet structure located at the northern embankment

This design will provide adequate storage for the water quality event above the wetland terrace. A small orifice that will be sized to convey base flows through the wetland will be provided at outlet structure. The water quality design flows and higher flows will exit the wetland through a discharge structure placed at the elevation predicted for the water quality design storm. As with Options 1A and 1B, based on the proposed dam height (Class A dam), the outlet structure will likely need to pass the 100-year event without overtopping the berm, depending on the final grading plan and dam height.

3. Hydrologic and Hydraulic Analysis

3.1 Analysis of Current Conditions

Brown and Caldwell prepared an existing conditions model for the basins draining to the DDFC by modifying the Storm Water Management Model for PC (PCSWMM) used for the 2009 Ellerbe Creek Watershed Management Improvement Plan. To provide more detailed drainage area runoff data for this design, the 230-acre Trinity Basin was divided into four subcatchments and the 255-acre Downtown Basin was divided into three subcatchments based on the stormwater drainage system and topographic information (see Figure 8).

In addition, City-provided GIS data was imported into the model to obtain detailed structure information for the culverts, pipes, and open channels upstream of the DDFC site to allow conveyance of the runoff from the 7 subcatchments; particularly for the two outfall culverts from Trinity and Downtown basins and the reach of open channel that represents South Ellerbe Creek (see Figure 9).

No stream flow data is available in the vicinity of the DDFC site for model calibration and verification, and observations of flooding or high water marks were not evident. Therefore, the revised basin flows were compared to the Ellerbe Creek Study results at the junction of the two basins and were found to have similar volumes, with peak flows varying for the range of events. In general, more frequent events resulted in increased peak flows for the DDFC model, with less frequent events resulting in peaks with smaller differences. Comparison data for these two models is provided in Table 1.

The results from the DDFC revised model were also compared to the results published by Duke University in a 2011 study of water quality and potential SCMs at the DDFC site (Allen 2011). The DDFC revised model produces similar runoff volumes to the SET Tool for the water quality, 1-year, and 2-year design storms.

Table 1. – Comparison of Model Results for DDFC Site

Event / Result		PCSWMM Model Results for Downtown and Trinity Basins		
		Ellerbe Creek Study	DDFC Revised Model	Percent Difference
Water Quality	Peak (cfs)	79	98	24%
	Vol (ac-ft)	24.5	25.4	4%
1-Year	Peak (cfs)	421	554	31%
	Vol (ac-ft)	92	95.5	4%
2-Year	Peak (cfs)	527	691	31%
	Vol (ac-ft)	110	114	4%
10-Year	Peak (cfs)	909	1065	17%
	Vol (ac-ft)	171	176	3%
25-Year	Peak (cfs)	1148	1296	13%
	Vol (ac-ft)	206	212	3%
100-Year	Peak (cfs)	n/a	1598	n/a
	Vol (ac-ft)	n/a	267	n/a

3.2 Analysis of Each Conceptual Design Alternative

3.2.1 Option 1A

The conceptual model for Option 1A included the following modifications to the DDFC Current Conditions model to simulate the conditions proposed in Section 2.1.1:

- A storage node was added to represent the storage and retention provided by the off-line wet pond for the Downtown Basin. This node was modeled as a reservoir with an invert of 310 ft MSL and a permanent pool elevation of 316 ft MSL.
- An outlet structure was added to the storage node consisting of a 2-inch orifice placed at the permanent pool elevation and three 12-foot long weirs set at an elevation of 320 ft MSL with a height of 4 feet to simulate an overflow spillway.

Preliminary results for the conceptual design (see Figure 5), indicate that Option 1A is capable of containing the entire water quality volume from the Downtown Basin without activating the overflow spillway set at 320 ft MSL. The modeled 2-inch orifice would allow for the water quality volume to discharge from the basin over 2-5 days. The preliminary results also show that the 100-year water surface elevation in the wet pond is less than 324.8 ft MSL, which is below the base flood elevation defined by FEMA for the regulated floodplain.

This indicates that the final spillway design should be able to route the 100-year peak flows without an increase in the base flood elevations, allowing the project to achieve a no-rise certification.

Results of the modeling for Option 1A are provided in Table 2. Since it appears that Option 1A may have excess storage capacity, it could be designed to provide additional benefits, such as stream channel protection by controlling the 1-year and 2-year flows, or flood reduction by reducing the base flood elevations for the 100-year event. However, those benefits would need to be compared to the cost savings realized by reducing the excavation costs and focusing only on water quality benefits.

Table 2 – Option 1A Modeling Results

Storm Event	Peak Flows (cfs)		Volume (ac-ft)	Max Water Surface Elevation (ft)
	Inflow	Outflow		
Water Quality	61.2	0.0	14.4	318.7
1	316	93	77	320.8
2	418	139	87	321.1
10	594	331	97	322.0
25	716	448	116	322.4
100	899	618	146	323.2

3.2.2 Option 1B

The conceptual model for Option 1B included the same modifications to the DDFC Current Conditions model as those described for the Option 1A model, with the following differences:

- A diversion node was added to divert water quality flows from the Trinity Basin into the off-line wet pond. This node was modeled as a 10-foot-square diversion box with an invert of 316 ft MSL (culvert invert) and a height of eight feet.
- Two weirs were connected to this node: (1) one diversion weir discharging at 316.3 ft MSL to the wet pond, and (2) one overflow bypass weir at elevation 320 ft MSL discharging into South Ellerbe Creek.
- The overflow spillway configuration for Option 1B consists of four 12'W X 4'H weirs set with invert elevations of 321 ft MSL to convey the required design flows.

Preliminary results for the conceptual design (see Figure 6), indicate that Option 1B is capable of containing the entire water quality volume from the Downtown and Trinity Basins without activating the overflow spillway set at 321 ft MSL. The modeled 2-inch orifice would allow for the water quality volume to discharge from the basin over 2-5 days. The preliminary results also show that the 100-year water surface elevation in the wet pond is less than 324.8 ft MSL, which is below the base flood elevation defined by FEMA for the regulated floodplain. This indicates that the final spillway design should be able to route the 100-year peak flows without an increase in the base flood elevations, allowing the project to achieve a no-rise certification.

Results of the modeling for Option 1B are provided in Table 3. (Note: Inflow, outflow and volume data are unavailable due to the complexity of the multi-outlet interconnected pond modeling required for this alternative; additional modeling to verify these results will be required if this option is selected).

Table 3 – Option 1B Modeling Results	
Storm Event	Max Water Surface Elevation (ft)
Water Quality	320.6
1	322.2
2	322.5
10	323.4
25	323.9
100	324.4

3.2.3 Option 2

The conceptual model for Option 2 included the following modifications to the DDFC Current Conditions model to simulate the conditions proposed in Section 2.2.

- A storage node was inserted to represent the storage and retention provided by the constructed wetland for both the Trinity and Downtown Basins. This node was modeled as a reservoir with a wetland terrace elevation and initial water surface elevations equal to 315 ft MSL.
- A 2-inch orifice was placed at the wetland terrace elevation to retain the water quality design flows for 2-5 days.
- Three 12'W X 4'H weirs were included to simulate an overflow spillway to provide conveyance of the required design flows. These weirs were set with an invert elevation of 320 ft MSL.

Preliminary results for the conceptual design (see Figure 7), indicate that Option 2 is capable of containing the entire water quality volume from the both the Trinity and Downtown Basins without activating the overflow spillway set at 320 ft MSL. The modeled 2-inch orifice would allow for the water quality volume to discharge from the basin over 2-5 days. The preliminary results also show that the 100-year water surface elevation in the constructed wetland is less than 324.8 ft MSL, which is below the base flood elevation defined by FEMA for the regulated floodplain. This indicates that the final spillway design should be able to route the 100-year peak flows without an increase in the base flood elevations, allowing the project to achieve a no-rise certification. Results of the modeling for Option 2 are provided in Table 4.

Table 4– Option 2 Modeling Results				
Storm Event	Peak Flows (cfs)		Volume (ac-ft)	Max Water Surface Elevation (ft)
	Inflow	Outflow		
Water Quality	109.2	0.1	25.1	319.0
1	573.5	195	94.5	321.4
2	794.2	279	113.5	321.8
10	1068.7	640	175.6	323.1
25	1370.1	836	211.1	323.7
100	1779.1	1121	266.6	324.7

4. Water Quality Evaluation

The water quality evaluation of each option was performed using the Jordan/Falls Lake Stormwater Load Accounting Tool, version 1.0 (JLSLAT). The JLSLAT uses rainfall and soils data for the contributing drainage basin, and detailed measurements of impervious areas within the contributing drainage area to estimate the inflow concentration and areal loading (in pounds per acre per year) of nitrogen and phosphorus for the project site. Based on the proposed stormwater control measure (SCM), such as wet ponds and constructed wetlands, the JLSLAT estimates the outflow concentrations and areal loading of nitrogen and phosphorus from the SCM to calculate the percent reduction in nutrient loads from the SCM.

4.1 General Input Data

For each of the SCM options developed for the DDFC project site, the following input data was applied in the JLSLAT:

- Physiographic region: Triassic Basin
- Hydrologic soils group: D soils
- Precipitation data location: Raleigh
- Total Development Area:
    - Trinity Basin = 230.1 acres (10,023,156 square feet)
    - Downtown Basin = 255.4 acres (11,124,512 square feet) for Option 1A
    - Combined Downtown and Trinity Basins = 485.5 acres (21,149,511 square feet) for Options 1B and 2
- Watershed Characteristics: based on impervious cover data and land use type, described in more detail below
- SCM Characteristics:
    - Wet Pond for Options 1A and 1B
    - Wetland for Option 2

4.2 Watershed Characteristics Input Data

Impervious cover data required for the JLSLAT is broken down by non-residential and residential land use types, and then into transportation and non-transportation related impervious areas. The data used to determine the impervious conditions for the Trinity and Downtown Basins is based on the existing land use information provided by the City of Durham, which includes aerial imagery, topography, parcels, zoning, impervious areas, and road centerlines (see Figure 10). Since both basins lack vacant land and are heavily urbanized and highly impervious, the existing land use data is a reasonable representation of future development conditions.

In general for the non-residential land use types, the aerial imagery was imported into AutoCAD to distinguish between buildings and parking lots within the impervious area data set, and then clipped with the commercial zoning layer and the industrial zoning layer. The resulting layers were used to determine the parking lot and roof areas for the commercial and industrial categories. To find the open/landscaped areas for commercial and industrial land use types, the measured impervious areas were subtracted from the total commercial or industrial zoned area.

For transportation, roads in commercial areas were assumed to have a width of 40 feet (based on measurements made in AutoCAD using aerial images) and assigned as high density. Roads in the industrial area were also assumed to have an average width of 40 feet and assigned as low density. The calculation of the sidewalk areas was based on commercial or industrial land use, sidewalk width, sidewalk location, and road length. The road length in each land use area (Commercial or Residential) was multiplied by an approximated sidewalk width to determine total sidewalk area. Assumptions included:

- Sidewalks are on both side of the street in commercial and industrial areas
- Sidewalks in commercial areas have an average width of 6 feet
- Sidewalks in industrial areas have an average width of 4 feet

The additional pervious areas, including managed pervious, unmanaged pervious, and forests, were determined in AutoCAD from the aerial images.

For residential land uses, it was assumed that areas of high density residential zones were 1/8 acre lots and medium density residential zones were 1/4 acre lots. The parcel data was imported to AutoCAD and a random sampling of parcel sizes was used to validate the assumption. All residential development was assumed to have occurred prior to 1995.

4.3 Results

The input data described above was input into the JLSLAT separately for each option. The results for Total Nitrogen are summarized below in Table A, and the results for Total Phosphorus are summarized in Table 6. As shown, the reduction in Total Nitrogen ranges from 30% to 35%, with a total annual reduction in nitrogen load ranging from 534 lbs to 1122 lbs.

The reduction in Total Phosphorus ranges from 48% to 55%, with a total annual reduction in phosphorus ranging from 140 lbs to 291 lbs. Result printouts from the JLSLAT are presented in Attachment B.

Table 5 JLSLAT Results for Total Nitrogen

Option	Inflow EMC	Outflow EMC	Total Inflow	Total Outflow	Total Annual Load Reduction	Percent Reduction
	(mg/L)	(mg/L)	(lb/ac/yr)	(lb/ac/yr)	(lb/yr)	
1A – Wet Pond for Downtown basin Only	1.42	1.05	7.06	4.97	534	30%
1B – Wet Pond for Trinity and Downtown Basins	1.48	1.06	6.52	4.42	1020	32%
2 – Wetland for Trinity and Downtown Basins	1.48	1.13	6.52	4.21	1122	35%

Note: Total Reduction for Option 1A is based on drainage area of 255.4 acres; total reduction for Options 1B and 2 is based on drainage area of 485.5 acres

Table 6 JLSLAT Results for Total Phosphorus

Option	Inflow EMC	Outflow EMC	Total Inflow	Total Outflow	Total Annual Load Reduction	Percent Reduction
	(mg/L)	(mg/L)	(lb/ac/yr)	(lb/ac/yr)	(lb/yr)	
1A – Wet Pond for Downtown basin Only	0.23	0.13	1.14	0.59	140	48%
1B – Wet Pond for Trinity and Downtown Basins	0.25	0.13	1.10	0.53	277	52%
2 – Wetland for Trinity and Downtown Basins	0.25	0.13	1.10	0.50	291	55%

Note: Total Reduction for Option 1A is based on drainage area of 255.4 acres; total reduction for Options 1B and 2 is based on drainage area of 485.5 acres

5. Summary of Results

Selection criteria for the best alternative include a review of each options potential for water quality benefits, hydrologic and hydraulic (H&H) performance characteristics and cost/constructability of each option. This memorandum contains Brown and Caldwell's preliminary analysis of H&H performance and water quality benefits for all three Options. A summary of the analysis results for each Option under the three selection criteria follows:

Water Quality Benefits

All three conceptual design alternatives can meet the water quality design requirements specified by the City of Durham for a wet pond (Options 1A and 1B) or constructed wetland (Option 2). Options 1B and Option 2 are preferred since they are able to treat the stormwater runoff from both the Trinity and Downtown Basins, while Option 1A only treats the stormwater runoff from the Downtown Basin. Option 2 provides the greatest levels of load reduction for both Total Nitrogen and Total Phosphorus; more than twice the total annual load reductions than Option 1A, and approximately 10% and 5% greater reductions for Total Nitrogen and Total Phosphorus than Option 1B, respectively.

H&H Performance

All three options were designed with the goal of storing and retaining the targeted water quality volumes for each basin and providing sufficient spillway capacity to convey high flow events (up to the 100-year storm). Options 1B and 2 would require a larger principal and emergency spillway (approximately 10%-20% more conveyance) than Option 1A since more of the live storage volume is being used by the water quality flows. However, it is expected that the cost difference between the spillway configurations would not significantly impact the overall cost of the project. In all three cases, the preliminary model results indicate that the 100-year water surface elevation is less than the base flood elevation published by FEMA for the regulated floodplain, which indicates that a no-rise certification could be obtained.

Project Costs

Costs for each conceptual design option are highly variable and dependent on the characteristics of the final design. For the purposes of this preliminary analysis, we have provided an estimate of the potential costs for each option using the cost estimating approach applied in the Ellerbe Creek Watershed Improvement Management Plan, but it should be noted that these comparisons are intended solely for the purpose of comparing options and should not be used for budgetary or project qualification purposes due to the high uncertainty that exists during the conceptual design phase of a project.

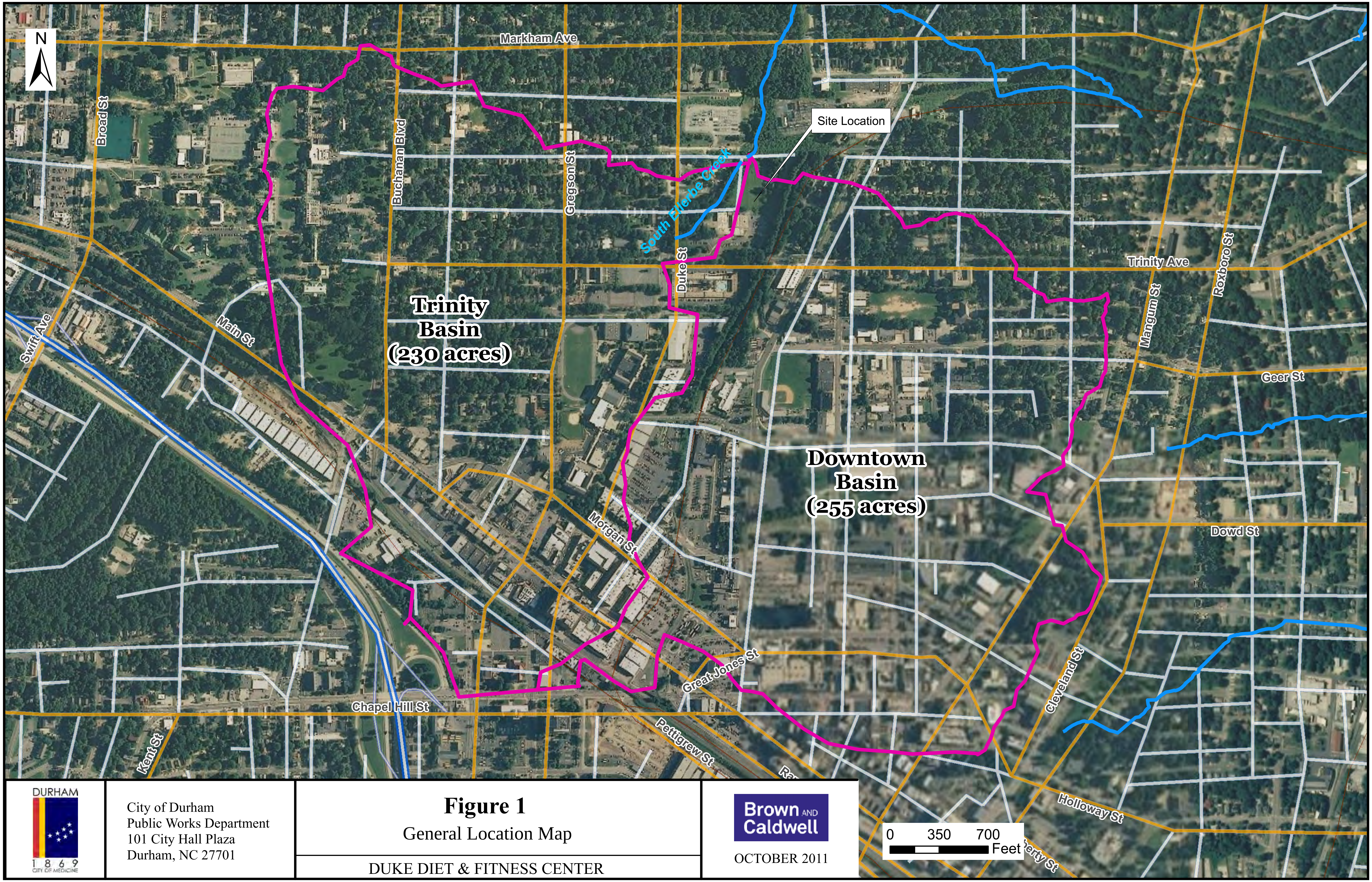
Projected costs for each option, excluding land acquisition costs and amenities, are presented in Table 7. A detailed breakdown for construction costs are provided in Attachment C.

Table 7 – Estimated Project Costs for Each Stormwater Retrofit Option			
Cost Item	Option 1A	Option 1B	Option 2
Disposal of Impacted Soil	$40,000	$40,000	$40,000
Asbestos Removal	$55,000	$55,000	$55,000
Site Demolition	$215,000	$215,000	$215,000
Stormwater Retrofit Construction Costs (See Attachment C)	$2,243,000	$2,273,000	$2,458,000
Construction Subtotal	**$2,553,000**	**$2,583,000**	**$2,768,000**
Construction Contingency (20%)	$511,000	$517,000	$554,000
Design, Permitting, and Construction Admin., (20%)	$511,000	$517,000	$554,000
Estimated Project Cost (excluding land acquisition and amenity costs)	**$3,575,000**	**$3,617,000**	**$3,876,000**

It should be noted that a significant portion of the costs are being driven by the amount of excavation for each of the options. This excavation, in part, is being driven by the need to meet the City's design spillway and freeboard requirements for lower frequency events. It is feasible that excavation amounts could be reduced if the spillway design requirements were altered.

In summary, Options 1B and 2 provide significantly higher levels of water quality treatment for Total Nitrogen and Total Phosphorus than Option 1A. Given the potential benefits versus the relatively small differential in cost, BC would recommend consideration of Option 2 as the best alternative for the Duke Diet and Fitness Center SCM retrofit.

Attachment A: Figures



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101 City Hall Plaza
Durham, NC 27701

Figure 1
General Location Map

DUKE DIET & FITNESS CENTER

Brown AND Caldwell

OCTOBER 2011

File: G:\Projects\Durham_NC\132215_Ellerbe\Map_Docs\200-Data_Collection\WS_Report\Fig1_1_Location_Map.mxd

DURHAM
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Public Works Department
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Durham, NC 27701

270 135 0
Feet

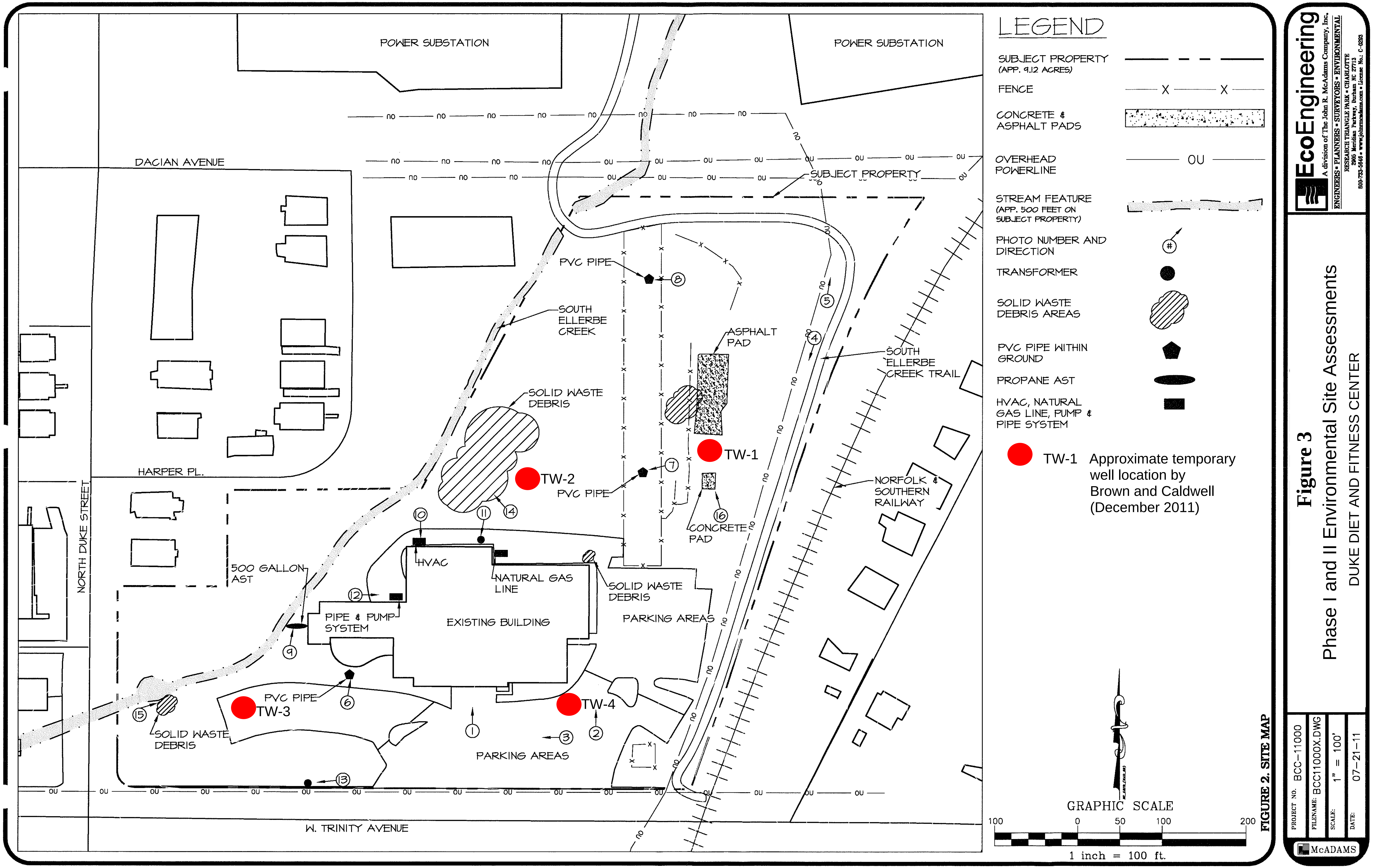
Figure 2
Existing Site Conditions
(Preliminary Draft)

Brown AND Caldwell

DATE:
September 2011

Prepared by Eco Engineering with Brown and Caldwell

Duke Diet and Fitness Center



POWER SUBSTATION
POWER SUBSTATION
DACIAN AVENUE
SUBJECT PROPERTY
PVC PIPE
SOUTH ELLERBE CREEK
ASPHALT PAD
SOUTH ELLERBE CREEK TRAIL
SOLID WASTE DEBRIS
TW-1
TW-2
PVC PIPE
HARPER PL.
NORTH DUKE STREET
NORFOLK & SOUTHERN RAILWAY
CONCRETE PAD
HVAC
NATURAL GAS LINE
500 GALLON AST
SOLID WASTE DEBRIS
PIPE & PUMP SYSTEM
EXISTING BUILDING
PARKING AREAS
PVC PIPE
TW-3
TW-4
SOLID WASTE DEBRIS
PARKING AREAS
W. TRINITY AVENUE
LEGEND
SUBJECT PROPERTY (APP. 9.12 ACRES)
FENCE
CONCRETE & ASPHALT PADS
OVERHEAD POWERLINE
OU
STREAM FEATURE (APP. 500 FEET ON SUBJECT PROPERTY)
PHOTO NUMBER AND DIRECTION
TRANSFORMER
SOLID WASTE DEBRIS AREAS
PVC PIPE WITHIN GROUND
PROPANE AST
HVAC, NATURAL GAS LINE, PUMP & PIPE SYSTEM
TW-1 Approximate temporary well location by Brown and Caldwell (December 2011)
GRAPHIC SCALE
100 0 50 100 200
1 inch = 100 ft.
FIGURE 2. SITE MAP
EcoEngineering
A division of The John R. McAdams Company, Inc.
ENGINEERS • PLANNERS • SURVEYORS • ENVIRONMENTAL
Figure 3
Phase I and II Environmental Site Assessments
DUKE DIET AND FITNESS CENTER
PROJECT NO. BCC-11000
FILENAME: BCC11000X.DWG
SCALE: 1" = 100'
DATE: 07-21-11
McADAMS

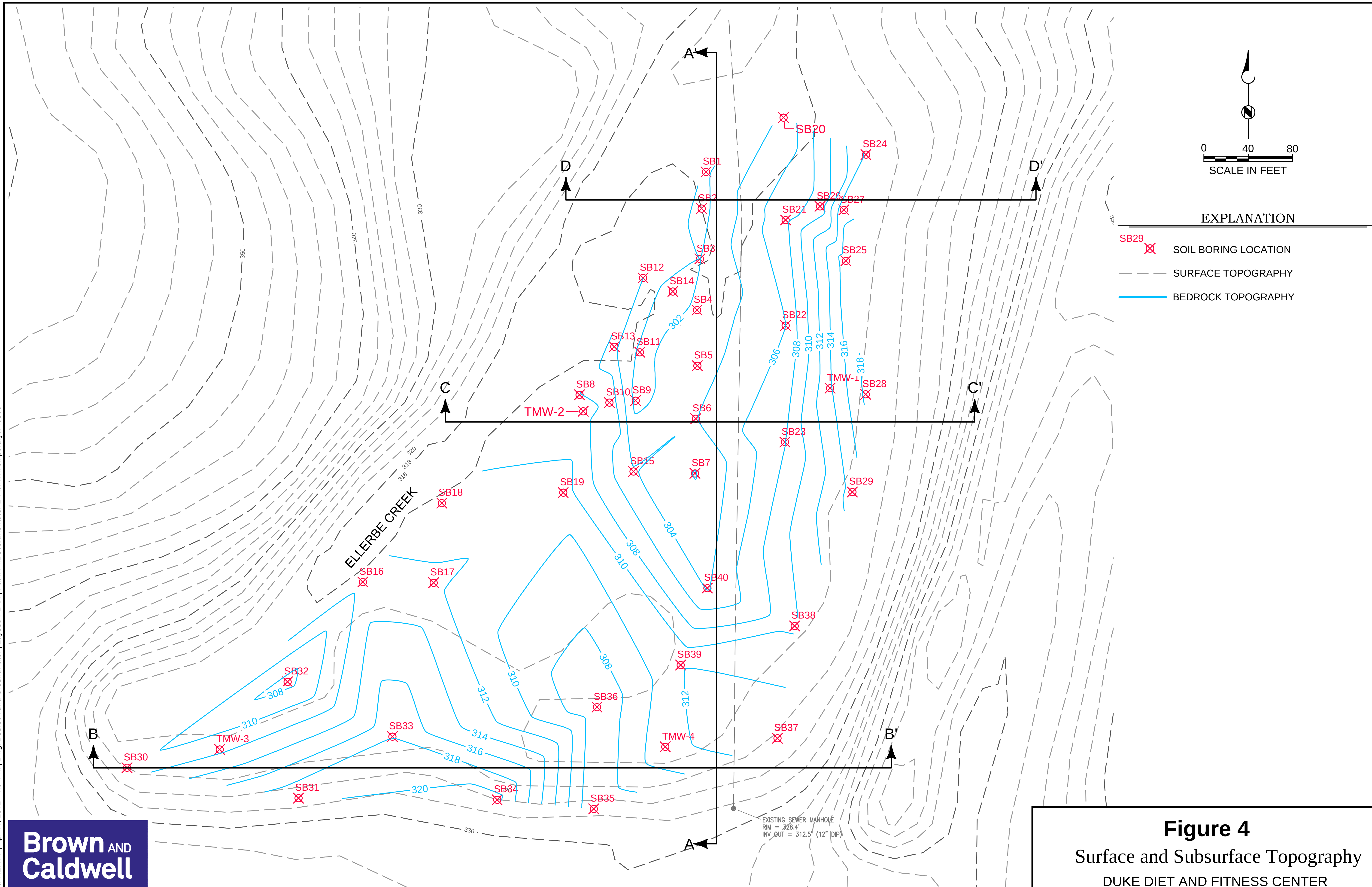
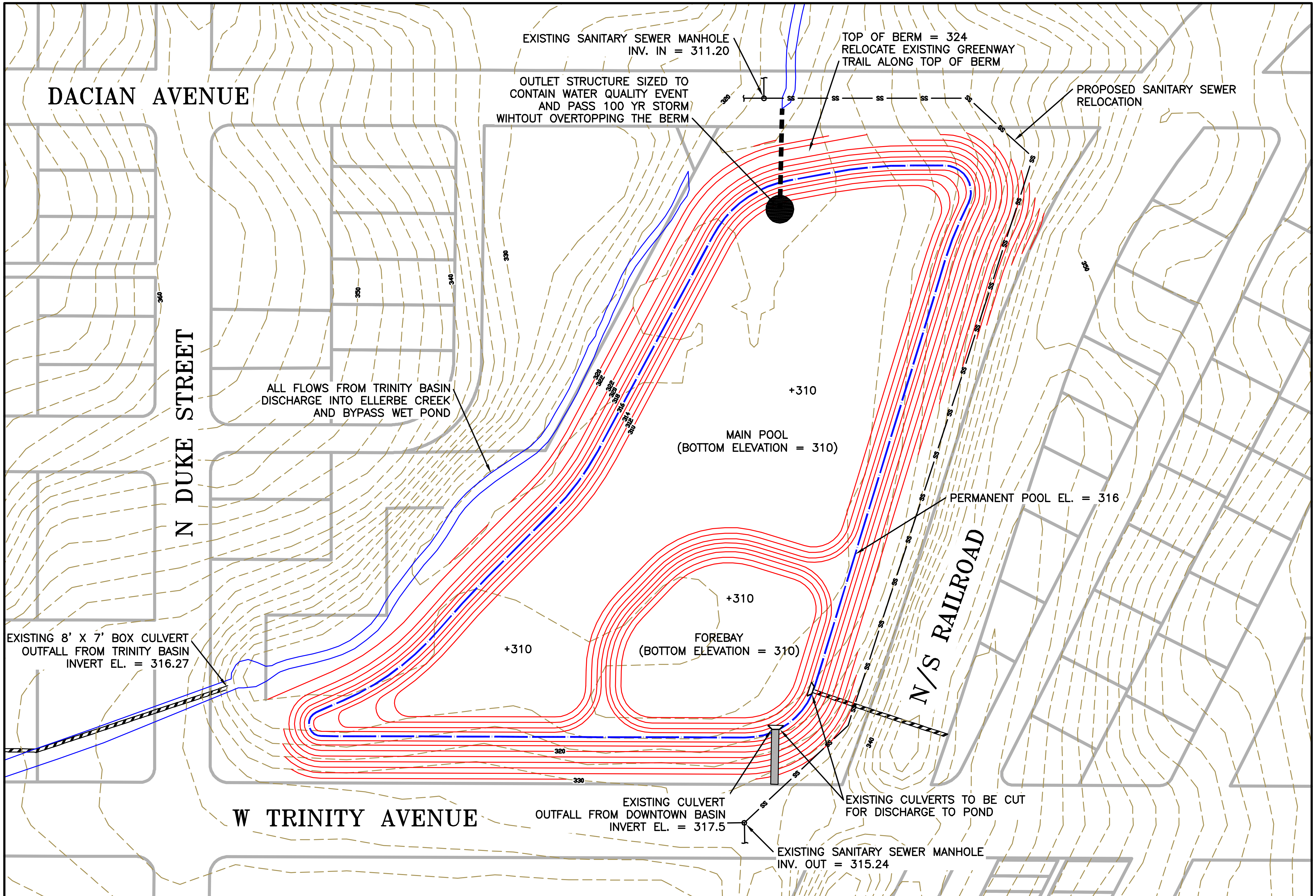


Figure 4

Surface and Subsurface Topography

DUKE DIET AND FITNESS CENTER

Brown AND Caldwell



OPTION 1A – WATER QUALTIY POND TO TREAT DOWNTOWN BASINS

Brown AND Caldwell

DATE: September 2011

Figure 5
Option 1A
(Preliminary Draft)

Duke Diet and Fitness Center

N

SCALE: 1"=100'

City of Durham
Public Works Department
101 City Hall Plaza
Durham, NC 27701

Prepared by Eco Engineering with Brown and Caldwell

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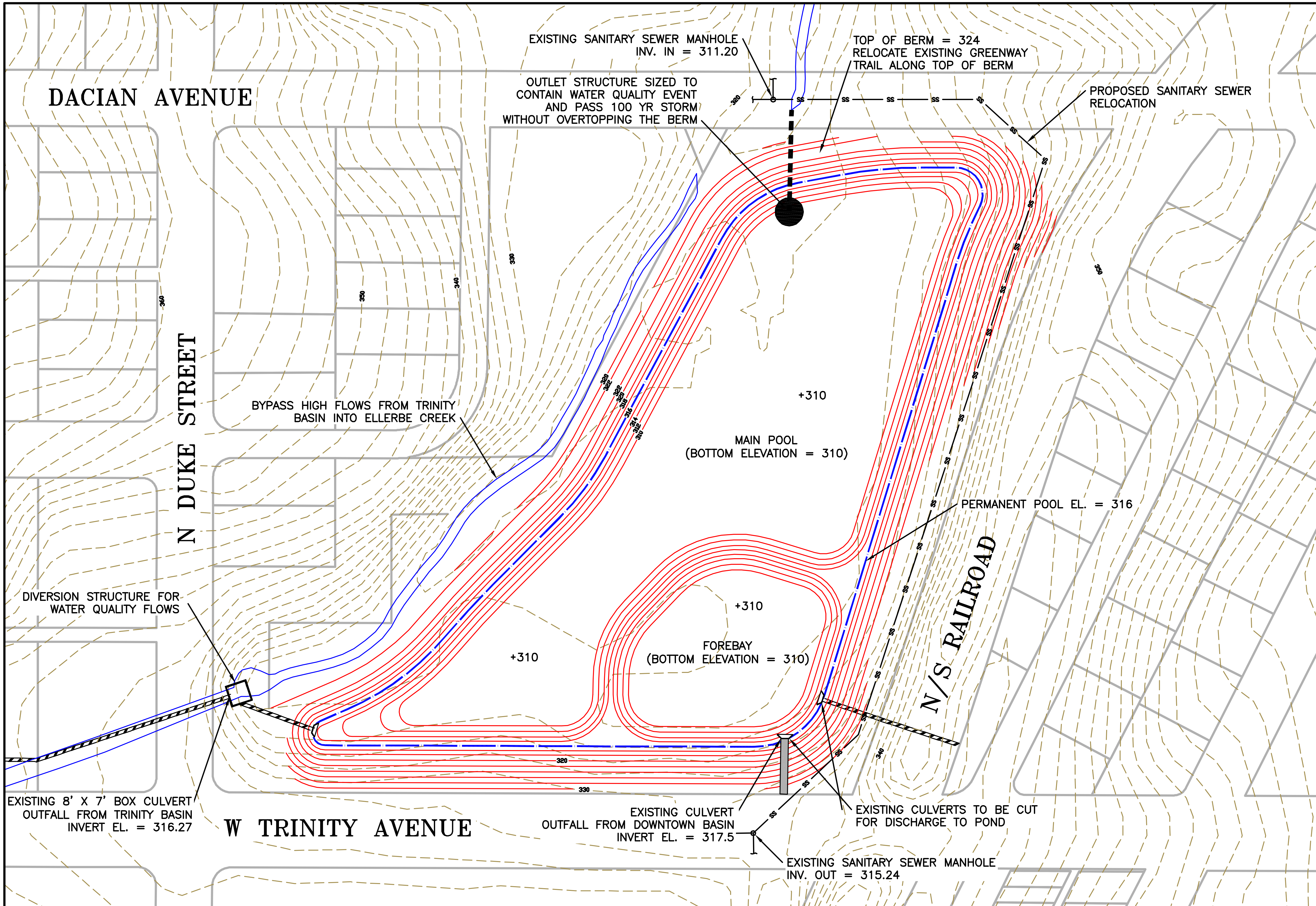

OPTION 1B – WATER QUALITY POND TO TREAT TRINITY AND DOWNTOWN BASINS

N

SCALE: 1"=100'

Figure 6
Option 1B
(Preliminary Draft)

Duke Diet and Fitness Center

Brown AND Caldwell

DATE:
September 2011

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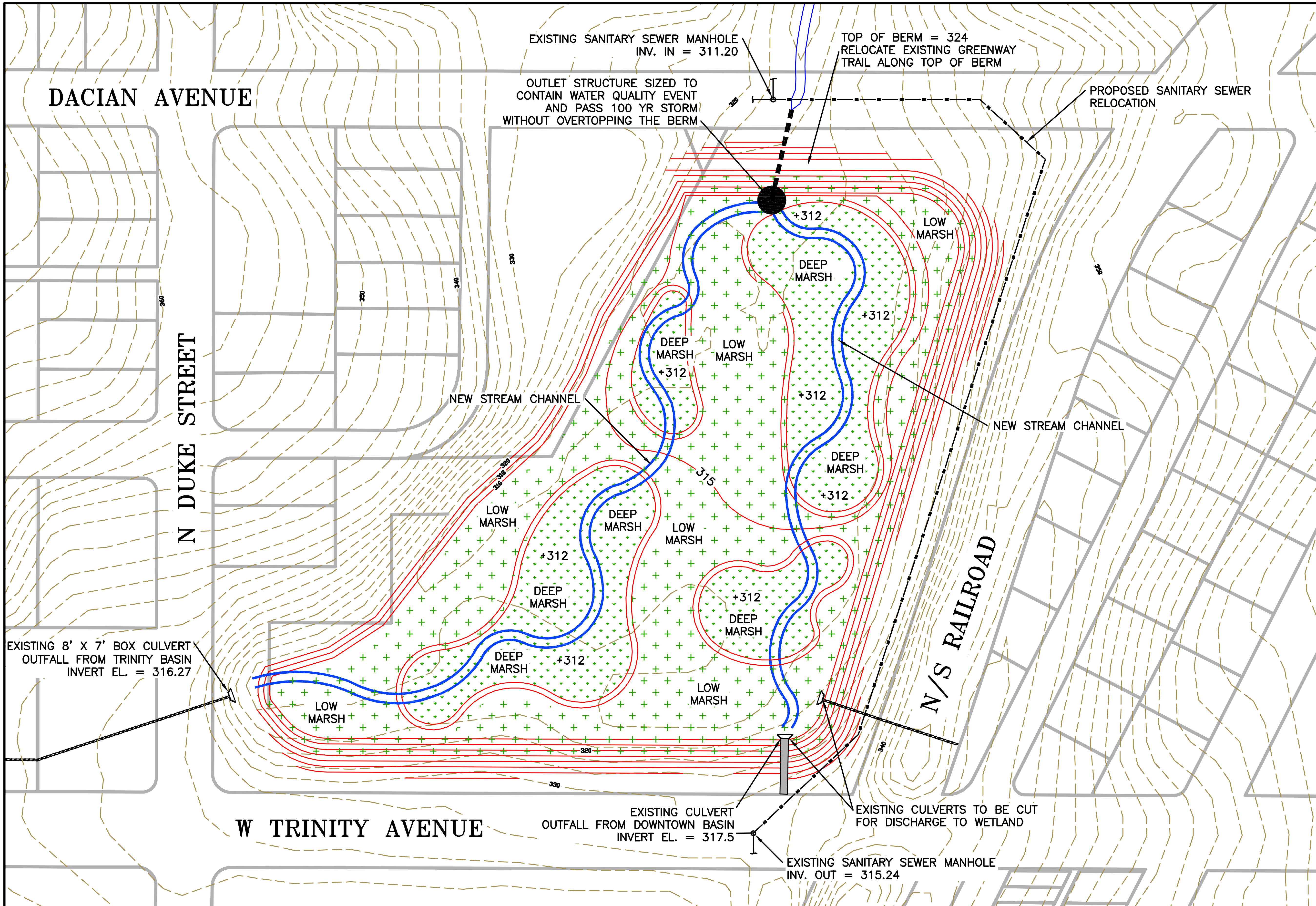

OPTION 2 – CONSTRUCTED WETLAND TO TREAT TRINITY AND DOWNTOWN BASINS

Brown AND Caldwell

DATE
September 2011

Figure 7
Option 2
(Preliminary Draft)

Duke Diet and Fitness Center

N

SCALE: 1"=100'

City of Durham
Public Works Department
101 City Hall Plaza
Durham, NC 27701

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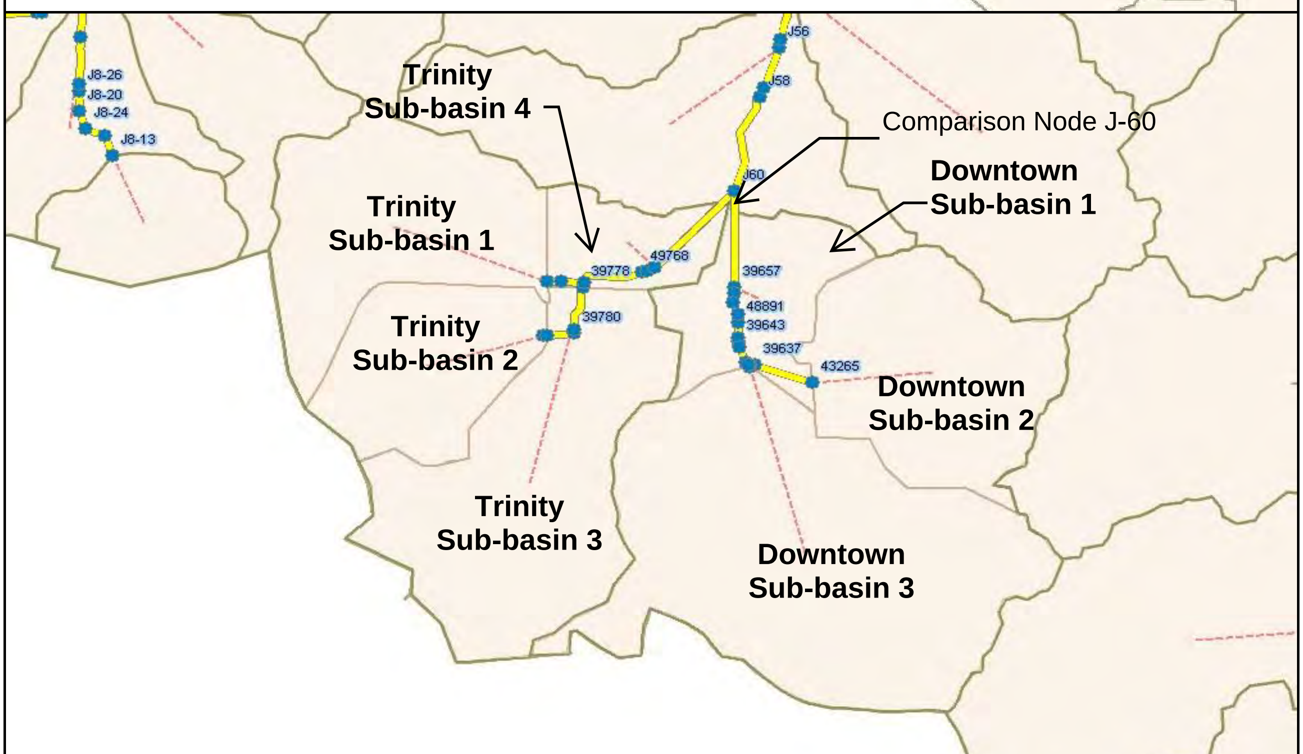


Revised Schematic for DDFC Model

DURHAM 1869 CITY OF MEDICINE	City of Durham Public Works Department 101 City Hall Plaza Durham, NC 27701	N	**Figure 8** **Comparison of Original to Detailed DDFC Model** DUKE DIET AND FITNESS CENTER	Brown AND Caldwell SEPTEMBER 2011

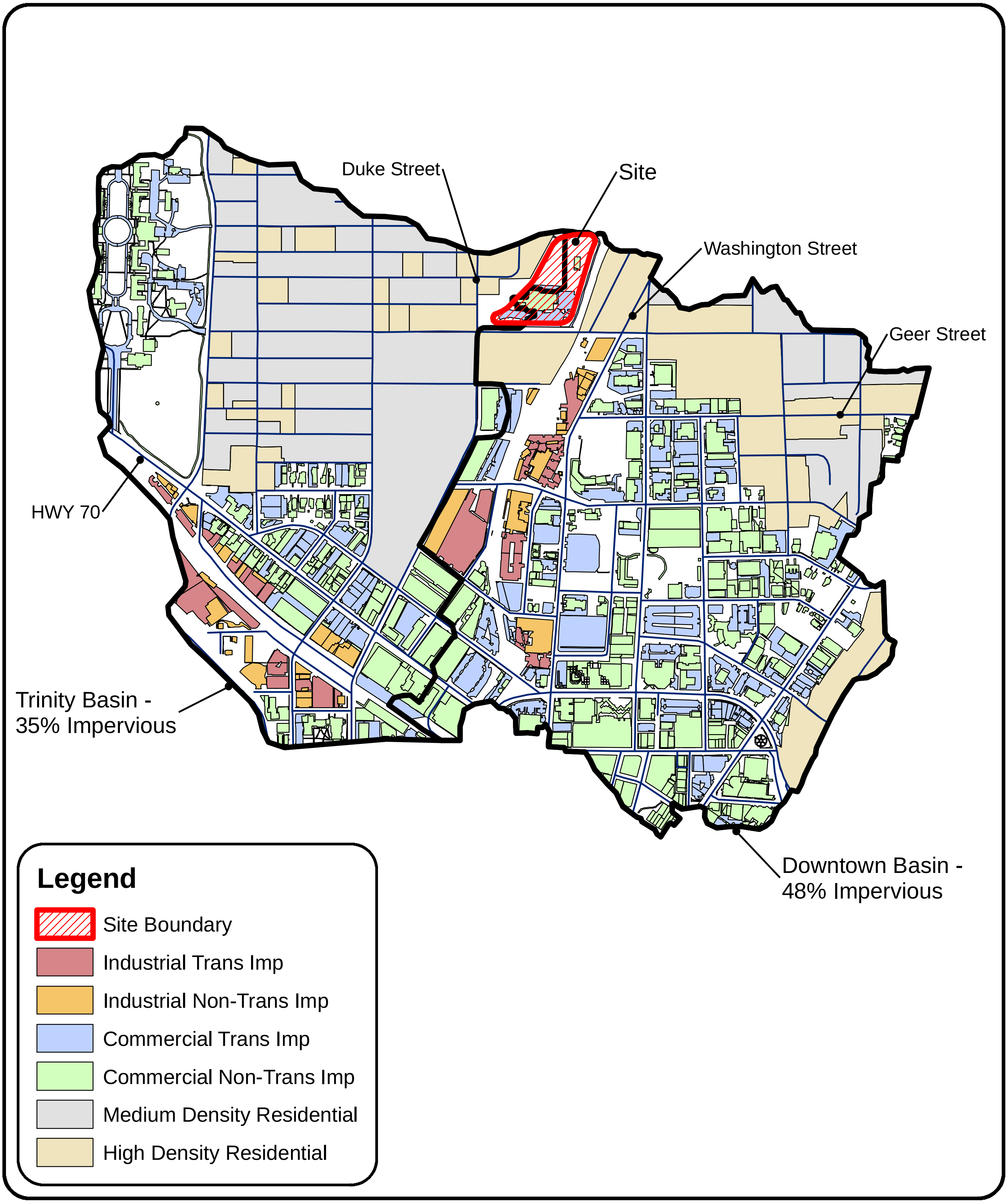
City of Durham
Public Works Department
101 City Hall Plaza
Durham, NC 27701

Figure 9
Current Conditions
DDFC Model

DUKE DIET AND FITNESS CENTER

Brown AND Caldwell

SEPTEMBER 2011



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Durham, NC 27701

Figure 10
Cover Conditions
(Preliminary Draft)

Brown AND Caldwell

DATE:
September 2011

Prepared by Eco Engineering with Brown and Caldwell

Duke Diet and Fitness Center

Attachment B: Jordan/Falls Lake Stormwater Load Accounting Tool Data

Physiographic/Geologic Region:	**Triassic Basin**
Soil Hydrologic Group	**D**
Precipitation location:	**Raleigh**

Total Development Area (ft^2):	**11,124,512**
Development Name:	DDFC Stormwater Facility - Option 1A
Model Prepared By:	Josh Shinn, EI

COLUMN 1 -- NON-RESIDENTIAL LAND USES

	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
COMMERCIAL				
Parking lot	1.44	0.16	1,466,609	1,466,609
Roof	1.08	0.15	2,409,263	2,409,263
Open/Landscaped	2.24	0.44	3,003,088	3,003,088
INDUSTRIAL				
Parking lot	1.44	0.39	311,302	311,302
Roof	1.08	0.15	259,118	259,118
Open/Landscaped	2.24	0.44	432,538	432,538
TRANSPORTATION				
High Density (interstate, main)	3.67	0.43	52,880	52,880
Low Density (secondary, feeder)	1.4	0.52	8,760	8,760
Rural	1.14	0.47	0	0
Sidewalk	1.4	1.16	17,616	17,616
PERVIOUS				
Managed pervious	3.06	0.59	187,220	187,220
Unmanaged (pasture)	3.61	1.56		
Forest	1.47	0.25		
JURISDICTIONAL LANDS*				
Natural wetland	--	--		
Riparian buffer	--	--		
Open water	--	--		
LAND TAKEN UP BY BMPs	1.08	0.15		

*Jurisdictional land uses are not included in nutrient/flow calculations.

COLUMN 2 -- RESIDENTIAL LAND USES

	Custom Lot Size (ac)	Age (yrs)	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
PART A						
⅛-ac lots	--	Before 1995	2.01873	0.4298	2,152,697	2,152,697
¼-ac lots	--	Before 1995	2.06662	0.42827	823,421	823,421
½-ac lots	--		--	--		
1-ac lots	--		--	--		
2-ac lots	--		--	--		
Multi-family	--		--	--		
Townhomes	--		--	--		
Custom Lot Size			--	--		
PART B						
Roadway		--	1.4	0.52		
Driveway		1.0	1.44	0.39		
Parking lot		--	1.44	0.39		
Roof		--	1.08	0.15		
Sidewalk/Patio		--	1.4	1.16		
Lawn		--	2.24	0.44		
Managed pervious		--	3.06	0.59		
Forest		--	1.47	0.25		
Natural wetland*		--	--	--		
Riparian buffer*		--	--	--		
Open water*		--	--	--		
LAND TAKEN UP BY BMPs		--	1.08	0.15		

LAND USE AREA CHECK

Total Development Area Entered (ft^2):	**11,124,512**
Total Pre-Development Calculated Area (ft^2):	**11,124,512**

	CATCHMENT 1			CATCHMENT 2			CATCHMENT 3			CATCHMENT 4			CATCHMENT 5			CATCHMENT 6			
	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	
Type of BMP:	**Wet Detention Pond**																		
If BMP is undersized, indicate the BMP's size relative to the design size required to capture the designated water quality depth (i.e. 0.75 = BMP is 75% of required design size):																			
***For water harvesting BMP, enter percent volume reduction in decimal form.**																			
	Does BMP accept the outflow from another Catchment? If so, indicate which one(s). (Land use areas entered below are in addition to the watershed areas treated by contributing catchment(s).)																		
Catchment 1:	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 2:	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 3:	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	
Catchment 4:	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	
Catchment 5:	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	
Catchment 6:	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	
Drainage Area Land Use	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Total Land Use Area Treated By All BMPs (ft^2)**
COMMERCIAL																			
Parking lot	1,466,609																		1,466,609
Roof	2,409,263																		2,409,263
Open/Landscaped	3,003,088																		3,003,088
INDUSTRIAL																			
Parking lot	311,302																		311,302
Roof	259,118																		259,118
Open/Landscaped	432,538																		432,538
TRANSPORTATION																			
High Density (interstate, main)	52,880																		52,880
Low Density (secondary, feeder)	8,760																		8,760
Rural	0																		0
Sidewalk	17,616																		17,616
MISC. PERVIOUS																			
Managed pervious	187,220																		187,220
Unmanaged (pasture)																			0
Forest																			0
RESIDENTIAL																			
2-ac lots (New)																			0
2-ac lots (Built after 1995)																			0
2-ac lots (Built before 1995)																			0
1-ac lots (New)																			0
1-ac lots (Built after 1995)																			0
1-ac lots (Built before 1995)																			0
½-ac lots (New)																			0
½-ac lots (Built after 1995)																			0
½-ac lots (Built before 1995)																			0
¼-ac lots (New)																			0
¼-ac lots (Built after 1995)																			0
¼-ac lots (Built before 1995)	823,421																		823,421
⅛-ac lots (New)																			0
⅛-ac lots (Built after 1995)																			0
⅛-ac lots (Built before 1995)	2,152,697																		2,152,697
Townhomes (New)																			0
Townhomes (Built after 1995)																			0
Townhomes (Built before 1995)																			0
Multi-family (New)																			0
Multi-family (Built after 1995)																			0
Multi-family (Built before 1995)																			0
Custom Lot Size (New)																			0
Custom Lot Size (Built after 1995)																			0
Custom Lot Size (Built before 1995)																			0
Roadway																			0
Driveway																			0
Parking lot																			0
Roof																			0
Sidewalk																			0
Lawn																			0
Managed pervious																			0
Forest																			0
LAND TAKEN UP BY BMP																			0
TOTAL AREA TREATED BY BMP (ft^2):	**11,124,512**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
TOTAL AREA TREATED BY SERIES (ft^2):		**11,124,512**			**0**			**0**			**0**			**0**			**0**		

Development:	**DDFC Stormwater Control Measure - Option 1A**
Prepared By:	Josh Shinn, EI
Date:	September 30, 2011

WATERSHED SUMMARY

REGION:	Triassic Basin		
TOTAL DEVELOPMENT AREA (ft^2):	11,124,512		
	Pre-Development Conditions	**Post-Development Conditions**	**Post-Development w/ BMPs**
Percent Impervious (%)	48.2%	48.2%	48.2%
Annual Runoff Volume (c.f.)	20,355,826	20,355,826	19,338,034
Total Nitrogen EMC (mg/L)	1.42	1.42	1.05
Total Nitrogen Loading (lb/ac/yr)	7.06	7.06	4.97
Total Phosphorus EMC (mg/L)	0.23	0.23	0.13
Total Phosphorus Loading (lb/ac/yr)	1.14	1.14	0.59

Percent Difference Between:

	Pre-Dev. & Post-Dev. without BMPs	**Pre-Development & Post-Development with BMPs**	**Post-Dev without BMPs & Post-Dev with BMPs**
Percent Impervious (%)	0%	0%	0%
Annual Runoff Volume (c.f.)	0%	-5%	-5%
Total Nitrogen EMC (mg/L)	0%	-26%	-26%
Total Nitrogen Loading (lb/ac/yr)	0%	-30%	-30%
Total Phosphorus EMC (mg/L)	1%	-45%	-46%
Total Phosphorus Loading (lb/ac/yr)	0%	-48%	-48%

*Negative percent difference values indicate a decrease in runoff volume, pollutant concentration or pollutant loading. Positive values indicate an increase.

BMP VOLUME REDUCTIONS/EFFLUENT CONCENTRATIONS

	Volume Reduction (%)	**TN Effluent Concen. (mg/L)**	**TP Effluent Concen. (mg/L)**
Bioretention with IWS	35%	0.95	0.12
Bioretention without IWS	15%	1.00	0.12
Dry Detention Pond	0%	1.20	0.20
Grassed Swale	0%	1.21	0.26
Green Roof	50%	1.08	0.15
Level Spdr, Filter Strip	20%	1.20	0.15
Permeable Pavement*	0%	1.44	0.39
Sand Filter	5%	0.92	0.14
Water Harvesting	user defined	1.08	0.15
Wet Detention Pond	5%	1.01	0.11
Wetland	15%	1.08	0.12

*if treating commercial parking lot, TP effluent concentration = 0.16 mg/L

Return to Instructions

Return to Watershed Characteristics

Return to BMP Characteristics

Print Summary

BMP SUMMARY

	CATCHMENT 1			**CATCHMENT 2**			**CATCHMENT 3**			**CATCHMENT 4**			**CATCHMENT 5**			**CATCHMENT 6**		
	BMP 1	**BMP 2**	**BMP 3**	**BMP 1**	**BMP 2**	**BMP 3**	**BMP 1**	**BMP 2**	**BMP 3**	**BMP 1**	**BMP 2**	**BMP 3**	**BMP 1**	**BMP 2**	**BMP 3**	**BMP 1**	**BMP 2**	**BMP 3**
	Wet Detention Pond	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Area Treated (ac)	255.38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Volume (c.f.)	20,355,826	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Percent Volume Reduced (%)	5%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Nitrogen EMC (mg/L)	1.42	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Nitrogen (lb/ac/yr)	7.06	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Phosphorus EMC (mg/L)	0.229	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Phosphorus (lb/ac/yr)	1.14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Nitrogen (lbs/ac/yr)	4.97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Phosphorus (lbs/ac/yr)	0.59	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	CATCHMENT 1	**CATCHMENT 2**	**CATCHMENT 3**	**CATCHMENT 4**	**CATCHMENT 5**	**CATCHMENT 6**
Catchment Outflow Nitrogen EMC (mg/L)	1.05	--	--	--	--	--
Catchment Outflow Total Nitrogen (lb/ac/yr)	4.97	--	--	--	--	--
Percent Reduction in Nitrogen Load (%)	30%	--	--	--	--	--
Catchment Outflow Phosphorus EMC (mg/L)	0.125	--	--	--	--	--
Catchment Outflow Total Phosphorus (lb/ac/yr)	0.591	--	--	--	--	--
Percent Reduction in Phosphorus Load (%)	48%	--	--	--	--	--

Physiographic/Geologic Region:	**Triassic Basin**
Soil Hydrologic Group	**D**
Precipitation location:	**Raleigh**

Total Development Area (ft^2):	**21,149,511**
Development Name:	DDFC Stormwater Facility - Option 1B
Model Prepared By:	Josh Shinn, EI

COLUMN 1 -- NON-RESIDENTIAL LAND USES

	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
COMMERCIAL				
Parking lot	1.44	0.16	2,202,164	2,202,164
Roof	1.08	0.15	3,570,227	3,570,227
Open/Landscaped	2.24	0.44	4,698,603	4,698,603
INDUSTRIAL				
Parking lot	1.44	0.39	566,294	566,294
Roof	1.08	0.15	455,652	455,652
Open/Landscaped	2.24	0.44	1,091,625	1,091,625
TRANSPORTATION				
High Density (interstate, main)	3.67	0.43	75,760	75,760
Low Density (secondary, feeder)	1.4	0.52	20,880	20,880
Rural	1.14	0.47	0	0
Sidewalk	1.4	1.16	26,904	26,904
PERVIOUS				
Managed pervious	3.06	0.59	843,980	843,980
Unmanaged (pasture)	3.61	1.56		
Forest	1.47	0.25	80,176	80,176
JURISDICTIONAL LANDS*				
Natural wetland	--	--		
Riparian buffer	--	--		
Open water	--	--		
LAND TAKEN UP BY BMPs	1.08	0.15		

*Jurisdictional land uses are not included in nutrient/flow calculations.

COLUMN 2 -- RESIDENTIAL LAND USES

	Custom Lot Size (ac)	Age (yrs)	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
PART A						
⅛-ac lots	--	Before 1995	2.01873	0.4298	3,031,173	3,031,173
¼-ac lots	--	Before 1995	2.06662	0.42827	4,486,073	4,486,073
½-ac lots	--		--	--		
1-ac lots	--		--	--		
2-ac lots	--		--	--		
Multi-family	--		--	--		
Townhomes	--		--	--		
Custom Lot Size			--	--		
PART B						
Roadway		--	1.4	0.52		
Driveway		1.0	1.44	0.39		
Parking lot		--	1.44	0.39		
Roof		--	1.08	0.15		
Sidewalk/Patio		--	1.4	1.16		
Lawn		--	2.24	0.44		
Managed pervious		--	3.06	0.59		
Forest		--	1.47	0.25		
Natural wetland*		--	--	--		
Riparian buffer*		--	--	--		
Open water*		--	--	--		
LAND TAKEN UP BY BMPs		--	1.08	0.15		

LAND USE AREA CHECK	
Total Development Area Entered (ft^2):	**21,149,511**
Total Pre-Development Calculated Area (ft^2):	**21,149,511**

	CATCHMENT 1			CATCHMENT 2			CATCHMENT 3			CATCHMENT 4			CATCHMENT 5			CATCHMENT 6			
	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	
Type of BMP:	**Wet Detention Pond**																		
If BMP is undersized, indicate the BMP's size relative to the design size required to capture the designated water quality depth (i.e. 0.75 = BMP is 75% of required design size):																			
***For water harvesting BMP, enter percent volume reduction in decimal form.**																			
	Does BMP accept the outflow from another Catchment? If so, indicate which one(s). (Land use areas entered below are in addition to the watershed areas treated by contributing catchment(s).)																		
Catchment 1:	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 2:	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 3:	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	
Catchment 4:	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	
Catchment 5:	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	
Catchment 6:	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	
Drainage Area Land Use	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Total Land Use Area Treated By All BMPs (ft^2)**
COMMERCIAL																			
Parking lot	2,202,164																		2,202,164
Roof	3,570,227																		3,570,227
Open/Landscaped	4,698,603																		4,698,603
INDUSTRIAL																			
Parking lot	566,294																		566,294
Roof	455,652																		455,652
Open/Landscaped	1,091,625																		1,091,625
TRANSPORTATION																			
High Density (interstate, main)	75,760																		75,760
Low Density (secondary, feeder)	20,880																		20,880
Rural	0																		0
Sidewalk	26,904																		26,904
MISC. PERVIOUS																			
Managed pervious	843,980																		843,980
Unmanaged (pasture)																			0
Forest	80,176																		80,176
RESIDENTIAL																			
2-ac lots (New)																			0
2-ac lots (Built after 1995)																			0
2-ac lots (Built before 1995)																			0
1-ac lots (New)																			0
1-ac lots (Built after 1995)																			0
1-ac lots (Built before 1995)																			0
½-ac lots (New)																			0
½-ac lots (Built after 1995)																			0
½-ac lots (Built before 1995)																			0
¼-ac lots (New)																			0
¼-ac lots (Built after 1995)																			0
¼-ac lots (Built before 1995)	4,486,073																		4,486,073
⅛-ac lots (New)																			0
⅛-ac lots (Built after 1995)																			0
⅛-ac lots (Built before 1995)	3,031,173																		3,031,173
Townhomes (New)																			0
Townhomes (Built after 1995)																			0
Townhomes (Built before 1995)																			0
Multi-family (New)																			0
Multi-family (Built after 1995)																			0
Multi-family (Built before 1995)																			0
Custom Lot Size (New)																			0
Custom Lot Size (Built after 1995)																			0
Custom Lot Size (Built before 1995)																			0
Roadway																			0
Driveway																			0
Parking lot																			0
Roof																			0
Sidewalk																			0
Lawn																			0
Managed pervious																			0
Forest																			0
LAND TAKEN UP BY BMP																			0
TOTAL AREA TREATED BY BMP (ft^2):	**21,149,511**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
TOTAL AREA TREATED BY SERIES (ft^2):		**21,149,511**			**0**			**0**			**0**			**0**			**0**		

Development:	DDFC Stormwater Control Measure - Option 1B
Prepared By:	Josh Shinn, EI
Date:	September 30, 2011

WATERSHED SUMMARY

REGION:	Triassic Basin
TOTAL DEVELOPMENT AREA (ft^2):	21,149,511

	Pre-Development Conditions	Post-Development Conditions	Post-Development w/ BMPs
Percent Impervious (%)	41.9%	41.9%	41.9%
Annual Runoff Volume (c.f.)	34,209,642	34,209,642	32,499,160
Total Nitrogen EMC (mg/L)	1.48	1.48	1.06
Total Nitrogen Loading (lb/ac/yr)	6.52	6.52	4.42
Total Phosphorus EMC (mg/L)	0.25	0.25	0.13
Total Phosphorus Loading (lb/ac/yr)	1.10	1.10	0.53

Percent Difference Between:

	Pre-Dev. & Post-Dev. without BMPs	Pre-Development & Post-Development with BMPs	Post-Dev without BMPs & Post-Dev with BMPs
Percent Impervious (%)	0%	0%	0%
Annual Runoff Volume (c.f.)	0%	-5%	-5%
Total Nitrogen EMC (mg/L)	0%	-28%	-28%
Total Nitrogen Loading (lb/ac/yr)	0%	-32%	-32%
Total Phosphorus EMC (mg/L)	2%	-49%	-50%
Total Phosphorus Loading (lb/ac/yr)	0%	-52%	-52%

*Negative percent difference values indicate a decrease in runoff volume, pollutant concentration or pollutant loading. Positive values indicate an increase.

BMP VOLUME REDUCTIONS/EFFLUENT CONCENTRATIONS

	Volume Reduction (%)	TN Effluent Concen. (mg/L)	TP Effluent Concen. (mg/L)
Bioretention with IWS	35%	0.95	0.12
Bioretention without IWS	15%	1.00	0.12
Dry Detention Pond	0%	1.20	0.20
Grassed Swale	0%	1.21	0.26
Green Roof	50%	1.08	0.15
Level Spdr, Filter Strip	20%	1.20	0.15
Permeable Pavement*	0%	1.44	0.39
Sand Filter	5%	0.92	0.14
Water Harvesting	user defined	1.08	0.15
Wet Detention Pond	5%	1.01	0.11
Wetland	15%	1.08	0.12

*if treating commercial parking lot, TP effluent concentration = 0.16 mg/L

Return to Instructions

Return to Watershed Characteristics

Return to BMP Characteristics

Print Summary

BMP SUMMARY

	CATCHMENT 1			CATCHMENT 2			CATCHMENT 3			CATCHMENT 4			CATCHMENT 5			CATCHMENT 6		
	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3
	Wet Detention Pond	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Area Treated (ac)	485.53	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Volume (c.f.)	34,209,642	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Percent Volume Reduced (%)	5%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Nitrogen EMC (mg/L)	1.48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Nitrogen (lb/ac/yr)	6.52	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Phosphorus EMC (mg/L)	0.250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Phosphorus (lb/ac/yr)	1.10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Nitrogen (lbs/ac/yr)	4.42	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Phosphorus (lbs/ac/yr)	0.53	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	Catchment 1	Catchment 2	Catchment 3	Catchment 4	Catchment 5	Catchment 6
Catchment Outflow Nitrogen EMC (mg/L)	1.06	--	--	--	--	--
Catchment Outflow Total Nitrogen (lb/ac/yr)	4.42	--	--	--	--	--
Percent Reduction in Nitrogen Load (%)	32%	--	--	--	--	--
Catchment Outflow Phosphorus EMC (mg/L)	0.127	--	--	--	--	--
Catchment Outflow Total Phosphorus (lb/ac/yr)	0.531	--	--	--	--	--
Percent Reduction in Phosphorus Load (%)	52%	--	--	--	--	--

Physiographic/Geologic Region:	**Triassic Basin**
Soil Hydrologic Group	**D**
Precipitation location:	**Raleigh**

Total Development Area (ft^2):	**21,149,511**
Development Name:	DDFC Stormwater Facility - Option 2
Model Prepared By:	Josh Shinn, EI

COLUMN 1 -- NON-RESIDENTIAL LAND USES

	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
COMMERCIAL				
Parking lot	1.44	0.16	2,202,164	2,202,164
Roof	1.08	0.15	3,570,227	3,570,227
Open/Landscaped	2.24	0.44	4,698,603	4,698,603
INDUSTRIAL				
Parking lot	1.44	0.39	566,294	566,294
Roof	1.08	0.15	455,652	455,652
Open/Landscaped	2.24	0.44	1,091,625	1,091,625
TRANSPORTATION				
High Density (interstate, main)	3.67	0.43	75,760	75,760
Low Density (secondary, feeder)	1.4	0.52	20,880	20,880
Rural	1.14	0.47	0	0
Sidewalk	1.4	1.16	26,904	26,904
PERVIOUS				
Managed pervious	3.06	0.59	843,980	843,980
Unmanaged (pasture)	3.61	1.56		
Forest	1.47	0.25	80,176	80,176
JURISDICTIONAL LANDS*				
Natural wetland	--	--		
Riparian buffer	--	--		
Open water	--	--		
LAND TAKEN UP BY BMPs	1.08	0.15		

*Jurisdictional land uses are not included in nutrient/flow calculations.

COLUMN 2 -- RESIDENTIAL LAND USES

	Custom Lot Size (ac)	Age (yrs)	TN EMC (mg/L)	TP EMC (mg/L)	Pre-Development (ft^2)	Post-Development (ft^2)
PART A						
⅛-ac lots	--	Before 1995	2.01873	0.4298	3,031,173	3,031,173
¼-ac lots	--	Before 1995	2.06662	0.42827	4,486,073	4,486,073
½-ac lots	--		--	--		
1-ac lots	--		--	--		
2-ac lots	--		--	--		
Multi-family	--		--	--		
Townhomes	--		--	--		
Custom Lot Size			--	--		
PART B						
Roadway		--	1.4	0.52		
Driveway		1.0	1.44	0.39		
Parking lot		--	1.44	0.39		
Roof		--	1.08	0.15		
Sidewalk/Patio		--	1.4	1.16		
Lawn		--	2.24	0.44		
Managed pervious		--	3.06	0.59		
Forest		--	1.47	0.25		
Natural wetland*		--	--	--		
Riparian buffer*		--	--	--		
Open water*		--	--	--		
LAND TAKEN UP BY BMPs		--	1.08	0.15		

LAND USE AREA CHECK	
Total Development Area Entered (ft^2):	**21,149,511**
Total Pre-Development Calculated Area (ft^2):	**21,149,511**

	CATCHMENT 1			CATCHMENT 2			CATCHMENT 3			CATCHMENT 4			CATCHMENT 5			CATCHMENT 6			
	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	BMP #1	BMP #2	BMP #3	
Type of BMP:	**Wetland**																		
If BMP is undersized, indicate the BMP's size relative to the design size required to capture the designated water quality depth (i.e. 0.75 = BMP is 75% of required design size):																			
***For water harvesting BMP, enter percent volume reduction in decimal form.**																			
	Does BMP accept the outflow from another Catchment? If so, indicate which one(s). (Land use areas entered below are in addition to the watershed areas treated by contributing catchment(s).)																		
Catchment 1:	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 2:	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	no	no	no	
Catchment 3:	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	no	no	no	
Catchment 4:	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	no	no	no	
Catchment 5:	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	no	no	no	
Catchment 6:	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	--	--	--	
Drainage Area Land Use	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Area Treated by BMP (ft^2)**	**Area treated by BMP #2 that is not treated by BMP #1 (ft^2)**	**Area treated by BMP #3 that is not treated by BMPs #1 or #2 (ft^2)**	**Total Land Use Area Treated By All BMPs (ft^2)**
COMMERCIAL																			
Parking lot	2,202,164																		2,202,164
Roof	3,570,227																		3,570,227
Open/Landscaped	4,698,603																		4,698,603
INDUSTRIAL																			
Parking lot	566,294																		566,294
Roof	455,652																		455,652
Open/Landscaped	1,091,625																		1,091,625
TRANSPORTATION																			
High Density (interstate, main)	75,760																		75,760
Low Density (secondary, feeder)	20,880																		20,880
Rural	0																		0
Sidewalk	26,904																		26,904
MISC. PERVIOUS																			
Managed pervious	843,980																		843,980
Unmanaged (pasture)																			0
Forest	80,176																		80,176
RESIDENTIAL																			
2-ac lots (New)																			0
2-ac lots (Built after 1995)																			0
2-ac lots (Built before 1995)																			0
1-ac lots (New)																			0
1-ac lots (Built after 1995)																			0
1-ac lots (Built before 1995)																			0
½-ac lots (New)																			0
½-ac lots (Built after 1995)																			0
½-ac lots (Built before 1995)																			0
¼-ac lots (New)																			0
¼-ac lots (Built after 1995)																			0
¼-ac lots (Built before 1995)	4,486,073																		4,486,073
⅛-ac lots (New)																			0
⅛-ac lots (Built after 1995)																			0
⅛-ac lots (Built before 1995)	3,031,173																		3,031,173
Townhomes (New)																			0
Townhomes (Built after 1995)																			0
Townhomes (Built before 1995)																			0
Multi-family (New)																			0
Multi-family (Built after 1995)																			0
Multi-family (Built before 1995)																			0
Custom Lot Size (New)																			0
Custom Lot Size (Built after 1995)																			0
Custom Lot Size (Built before 1995)																			0
Roadway																			0
Driveway																			0
Parking lot																			0
Roof																			0
Sidewalk																			0
Lawn																			0
Managed pervious																			0
Forest																			0
LAND TAKEN UP BY BMP																			0
TOTAL AREA TREATED BY BMP (ft^2):	**21,149,511**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
TOTAL AREA TREATED BY SERIES (ft^2):		**21,149,511**			**0**			**0**			**0**			**0**			**0**		

Development:	**DDFC Stormwater Control Measure - Option 2**
Prepared By:	Josh Shinn, EI
Date:	September 30, 2011

WATERSHED SUMMARY

REGION:	Triassic Basin
TOTAL DEVELOPMENT AREA (ft^2):	21,149,511

	Pre-Development Conditions	Post-Development Conditions	Post-Development w/ BMPs
Percent Impervious (%)	41.9%	41.9%	41.9%
Annual Runoff Volume (c.f.)	34,209,642	34,209,642	29,078,195
Total Nitrogen EMC (mg/L)	1.48	1.48	1.13
Total Nitrogen Loading (lb/ac/yr)	6.52	6.52	4.21
Total Phosphorus EMC (mg/L)	0.25	0.25	0.13
Total Phosphorus Loading (lb/ac/yr)	1.10	1.10	0.49

Percent Difference Between:

	Pre-Dev. & Post-Dev. without BMPs	Pre-Development & Post-Development with BMPs	Post-Dev without BMPs & Post-Dev with BMPs
Percent Impervious (%)	0%	0%	0%
Annual Runoff Volume (c.f.)	0%	-15%	-15%
Total Nitrogen EMC (mg/L)	0%	-24%	-24%
Total Nitrogen Loading (lb/ac/yr)	0%	-35%	-35%
Total Phosphorus EMC (mg/L)	2%	-47%	-48%
Total Phosphorus Loading (lb/ac/yr)	0%	-55%	-55%

*Negative percent difference values indicate a decrease in runoff volume, pollutant concentration or pollutant loading. Positive values indicate an increase.

BMP VOLUME REDUCTIONS/EFFLUENT CONCENTRATIONS

	Volume Reduction (%)	TN Effluent Concen. (mg/L)	TP Effluent Concen. (mg/L)
Bioretention with IWS	35%	0.95	0.12
Bioretention without IWS	15%	1.00	0.12
Dry Detention Pond	0%	1.20	0.20
Grassed Swale	0%	1.21	0.26
Green Roof	50%	1.08	0.15
Level Spdr, Filter Strip	20%	1.20	0.15
Permeable Pavement*	0%	1.44	0.39
Sand Filter	5%	0.92	0.14
Water Harvesting	user defined	1.08	0.15
Wet Detention Pond	5%	1.01	0.11
Wetland	15%	1.08	0.12

*if treating commercial parking lot, TP effluent concentration = 0.16 mg/L

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Return to Watershed Characteristics

Return to BMP Characteristics

Print Summary

BMP SUMMARY

	CATCHMENT 1			CATCHMENT 2			CATCHMENT 3			CATCHMENT 4			CATCHMENT 5			CATCHMENT 6		
	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3	BMP 1	BMP 2	BMP 3
	Wetland	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Area Treated (ac)	485.53	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Volume (c.f.)	34,209,642	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Percent Volume Reduced (%)	15%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Nitrogen EMC (mg/L)	1.48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Nitrogen (lb/ac/yr)	6.52	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inflow Phosphorus EMC (mg/L)	0.250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Inflow Phosphorus (lb/ac/yr)	1.10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Nitrogen (lbs/ac/yr)	4.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BMP Outflow Phosphorus (lbs/ac/yr)	0.49	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Catchment Outflow Nitrogen EMC (mg/L)	1.13	--	--	--	--	--
Catchment Outflow Total Nitrogen (lb/ac/yr)	4.21	--	--	--	--	--
Percent Reduction in Nitrogen Load (%)	35%	--	--	--	--	--
Catchment Outflow Phosphorus EMC (mg/L)	0.133	--	--	--	--	--
Catchment Outflow Total Phosphorus (lb/ac/yr)	0.495	--	--	--	--	--
Percent Reduction in Phosphorus Load (%)	55%	--	--	--	--	--

Attachment C: Preliminary Cost Estimates

Preliminary Cost Estimate - DDFC Stormwater Control Measure Option 1A

Bid Item Description	Type	Unit Rate	Units	Quantity	Subtotal
Temporary Road	Fixed	$10.00	SY	500	$5,000
Clear and Grub	Variable	$2.70	SY	39,000	$105,300
Construction Entrance	Fixed	$28.00	SY	90	$2,500
Geotextile Underliner for above	Fixed	$3.00	SY	250	$800
Construct New Outlet Structure	Fixed	$9,000.00	EA	1	$9,000
New Piping (48" RCP)	Fixed	$120.00	LF	150	$18,000
Excavate (for volume)	Variable	$14.00	CY	83,500	$1,169,000
Haul Away Excavated Material	Variable	$10.00	CY	83,500	$835,000
Placing Additional Material on Berms	Fixed	$20.00	CY	1300	$26,000
Backfill pipe excavation	Fixed	$20.00	CY	85	$1,700
Flowable fill for pipe excavation	Fixed	$150.00	CY	20	$3,000
Precast single 48" endwall for outlet pipe	Fixed	$6,500.00	EA	1	$6,500
Emergency spillway	Fixed	$15,000.00	EA	1	$15,000
Finish Grading	Variable	$1.50	SY	20,000	$30,000
Stock Pond	Fixed	$700.00	EA	1	$700
Plantings	Variable	$10.00	SY	1,500	$15,000
				Construction Subtotal =	*$2,242,500*

Preliminary Cost Estimate - DDFC Stormwater Control Measure Option 1B

Bid Item Description	Type	Unit Rate	Units	Quantity	Subtotal
Temporary Road	Fixed	$10.00	SY	500	$5,000
Clear and Grub	Variable	$2.70	SY	39,000	$105,300
Construction Entrance	Fixed	$28.00	SY	90	$2,500
Geotextile Underliner for above	Fixed	$3.00	SY	250	$800
Construct New Outlet Structure	Fixed	$9,000.00	EA	1	$9,000
Construct Diversion Structure	Fixed	$35,000.00	EA	1	$35,000
New Piping (48" RCP)	Fixed	$120.00	LF	150	$18,000
Excavate (for volume)	Variable	$14.00	CY	83,500	$1,169,000
Haul Away Excavated Material	Variable	$10.00	CY	83,500	$835,000
Placing Additional Material on Berms	Fixed	$20.00	CY	1300	$26,000
Backfill pipe excavation	Fixed	$20.00	CY	85	$1,700
Flowable fill for pipe excavation	Fixed	$150.00	CY	20	$3,000
Precast single 48" endwall for outlet pipe	Fixed	$6,500.00	EA	1	$6,500
Emergency spillway	Fixed	$15,000.00	EA	1	$15,000
Finish Grading	Variable	$1.50	SY	20,000	$30,000
Stock Pond	Fixed	$700.00	EA	1	$700
Plantings	Variable	$10.00	SY	1,500	$15,000
				Construction Subtotal =	*$2,272,500*

Preliminary Cost Estimate - DDFC Stormwater Control Measure Option 2

Bid Item Description	Type	Unit Rate	Units	Quantity	Subtotal
Temporary Road	Fixed	$10.00	SY	500	$5,000
Clear, Grub and Demo	Variable	$2.70	SY	40,500	$109,400
Construction Entrance	Fixed	$28.00	SY	90	$2,500
Geotextile Underliner for above	Fixed	$3.00	SY	250	$800
Construct New Outlet Structure	Fixed	$9,000.00	EA	1	$9,000
Excavate (for volume)	Variable	$14.00	CY	71,000	$994,000
Haul Away Excavated Material	Variable	$10.00	CY	71,000	$710,000
Placing Additional Material on Berms	Fixed	$20.00	CY	1300	$26,000
Organic Fill/Top Soil	Variable	$10.00	SY	28,500	$285,000
Rip Rap	Fixed	$60.00	TON	70	$4,200
Finish Grading	Variable	$1.50	SY	18,000	$27,000
Plantings	Variable	$10.00	SY	28,500	$285,000
				Construction Subtotal =	*$2,457,900*